Modelling the dispersal of microplastic particles: anthropogenic cohesive particles and their fate in coastal waters

Erik Toorman[1], Qilong Bi[1], Xiaoteng Shen[1], Annika Jahnke[2] and Jaak Monbaliu[1]

[1] Hydraulics Division, Department of Civil Engineering
KU Leuven, Kasteelpark Arenberg 40, box 2448, B-3001 Leuven, Belgium
E-mail: erik.toorman@kuleuven.be

[2] Department of Cell Toxicology, Helmholtz Centre for Environmental Research -- UFZ
Permoserstrasse 15, DE- 04318 Leipzig, Germany

Introduction

Microplastic (MP) particles are small plastic particles with a size smaller than 5 mm, which are found in all kinds of products (paints, shower gels, etc) or result from the degradation by weathering of macroplastics by exposure to UV radiation, biotic degradation, friction, etc. These particles enter the aquatic environment via sewer inflows, sewer treatment plant overflows, or direct input from waste through rainfall runoff or from the air. These particles are believed to be a threat to the environment since during the weathering process they break up into food-sized particles and may leach toxic additives that may enter the food chain. Recent monitoring has revealed an astonishing amount of MP particles deposited in sediments along shores down to the deep ocean bottom. Thus far, little is known about the time scales and pathways for the transport of MP particles and the governing processes (Jahnke *et al.*, 2017b). The JPI Oceans funded project WEATHER-MIC (Jahnke *et al.*, 2017a) aims at investigating this aspect. Since MP particles show many similarities with cohesive sediment particles (e.g. surface charges and biofilm formation), the KU Leuven applies their expertise on cohesive sediment transport modelling to these "new" particles, including the possible interaction with cohesive particles in the aquatic environment.

Modelling of microplastics dispersal

The KU Leuven contributes to this project by setting up 3D particle transport models for two sites, i.e. the Oslo Fjord (Norway) and the Himmerfjärden Bay, south of Stockholm (Sweden), using the TELEMAC software (www.openTELEMAC.org). Open sea boundary conditions are generated by a two-dimensional depth-averaged (2DH) hydrodynamic model for the wider area covering the Skaggerak, Kattegat and Baltic Sea, in which tidal currents and wind effects are considered. Field data are collected by the Norwegian Geotechnical Institute (NGI) and Stockholm University, partners in the project.

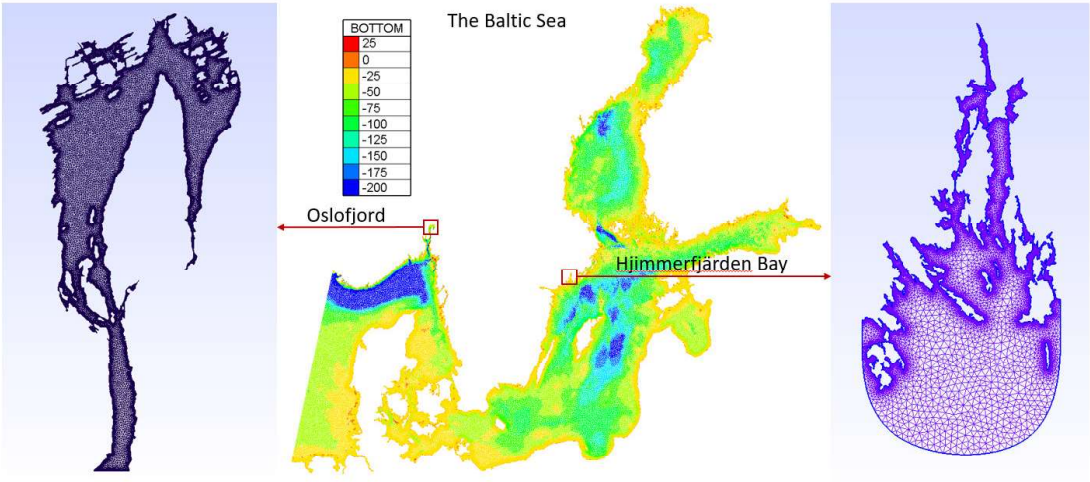

Figure 1. The unstructured meshes for the 2DH Baltic Sea model, and the 3D Oslo Fjord and Himmerfjärden Bay models

The main challenge is the development of a closure model to predict the highly variable size, density and settling velocity of the particles and their aggregates. For this purpose, the two-class population balance equation (2CPBE) flocculation model, developed by Lee *et al.* (2011), and

implemented into TELEMAC (Ernst, 2016), will be extended to 3 classes (Shen *et al.*, 2017) and adapted to be applicable to MP particles (class 1), cohesive sediment particles (class 2) and their combined flocs (class 3). Since so little is known on the changing properties of MP particles by weathering, biofilm formation and aggregation, dedicated experiments are carried out in settling columns at NGI.

Characterization of weathering microplastic particles

Complementary research is carried out by the Helmholtz Center for Environmental Research (UFZ Leipzig), Fraunhofer Institute (IKTS Dresden), the Department of Environmental Science and Analytical Chemistry (Stockholm University) and NGI (Oslo) by experimental studies to gain understanding of weathering mechanisms and their environmental impact. The effect of the following factors on MP weathering is investigated: UV light exposure, salinity, physical stress (turbulence and friction with other particles, including sediments), biodegradation, biofilm formation and temperature. The outcome of these investigations needs to be transformed into breakup and aggregation terms for the particle kinetics equations in order to calculate the evolution of the average settling velocities of MP particles and its aggregates.

For many of the partners this is the first application of their expertise to MP, which results in the innovative use of methodologies and measuring techniques never before applied to these particles.

Further information can be found on the project website http://www.jpi-oceans.eu/weather-mic/about

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